Software-Intensive Systems Producibility Research

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Presentation Overview

- Agenda
  - DoD's needs for producing Software-Intensive Systems
    - F-22, SBIRS High
    - Future Developments
  - Current efforts to address Software-Intensive Systems (SIS) Producibility
  - Envisioned program

DoD's SIS Challenge

"DoD estimates that it spends about 40% of its RDT&E budget on software - $21B for FY2003" – GAO

F-22

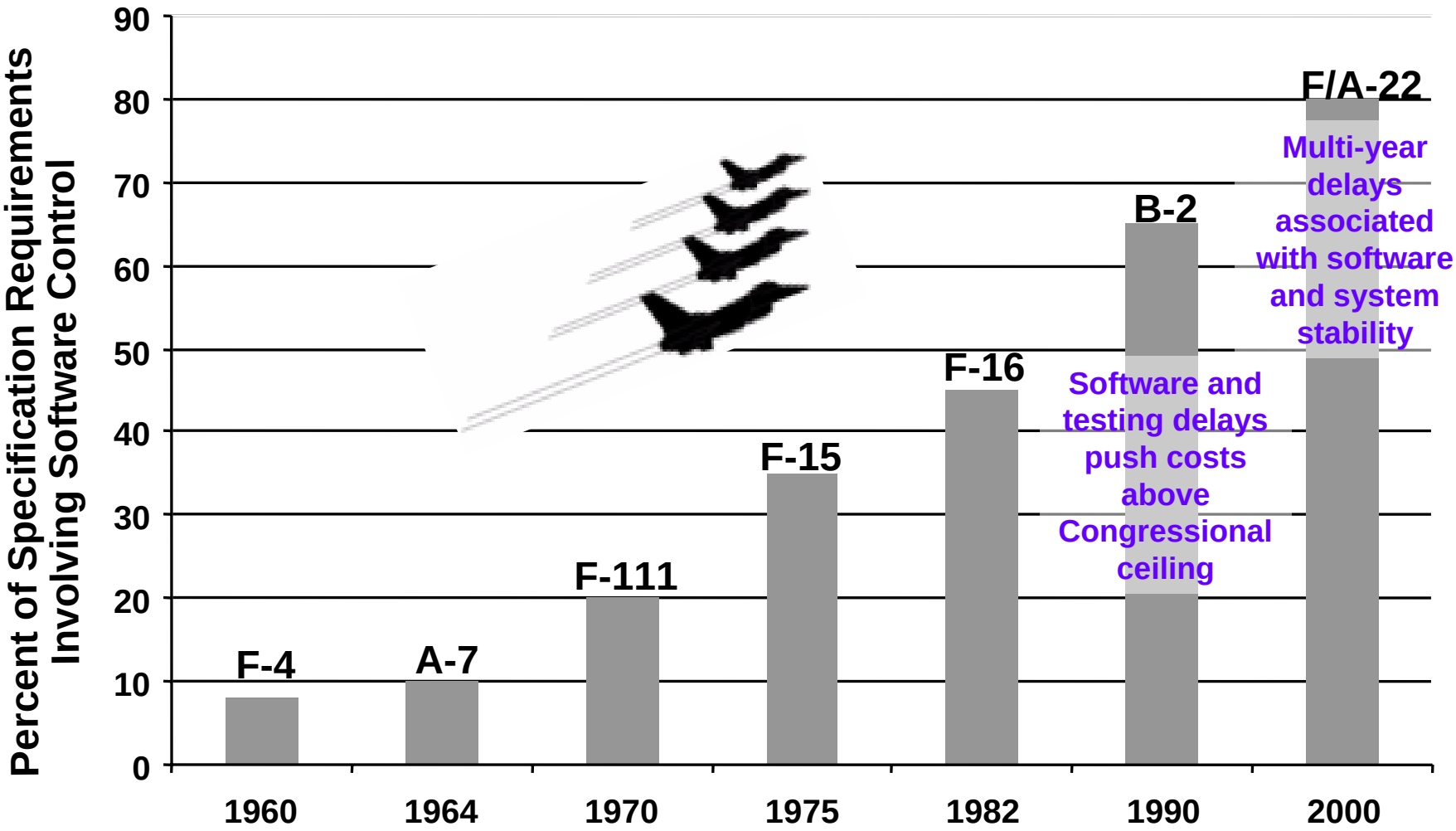
SBIRS-High

"[Software] continues to grow in importance in our weapons systems - and remains a significant contributor to program cost, schedule and performance shortfalls." -- Pete Aldridge

Opportunities for Improvement

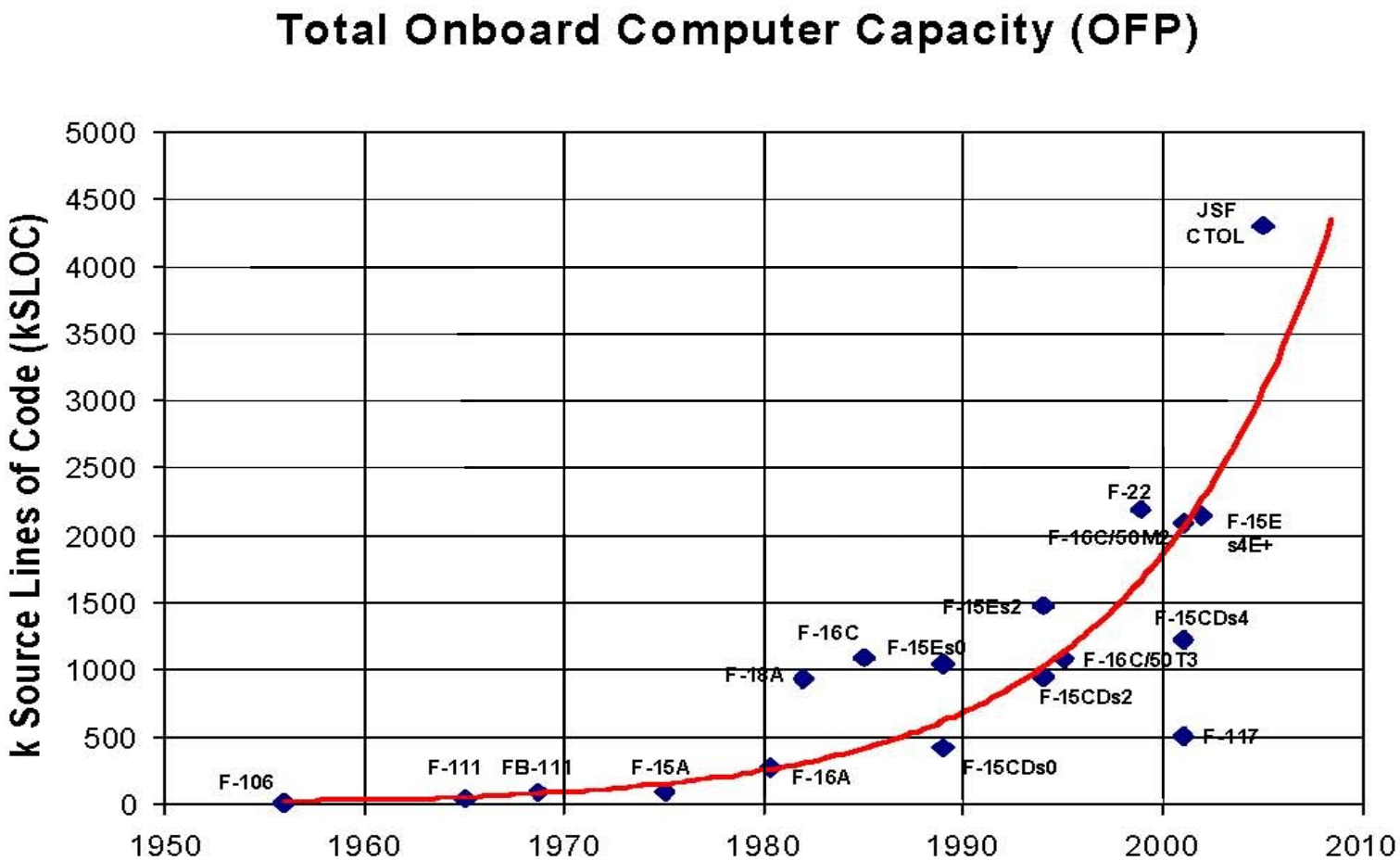
- Development tools do not adequately provide system-level awareness
  - Start-up, shut-down, reconfiguration
  - Establish, track, assess system-level properties
    - Reliability, Resource utilization, Deadlines etc.
  - Enforcement of design principles during development
- Development details still dominated by expert involvement and peer reviews

Capability Provided by Software in DoD Systems is Increasing but so are the Challenges…



Ref: Defense Systems Management College

DoD Software is Growing in Size and Complexity



Source: "Avionics Acquisition, Production, and Sustainment: Lessons Learned -- The Hard Way", NDIA Systems Engineering Conference, Mr. D. Gary Van Oss, October 2002.

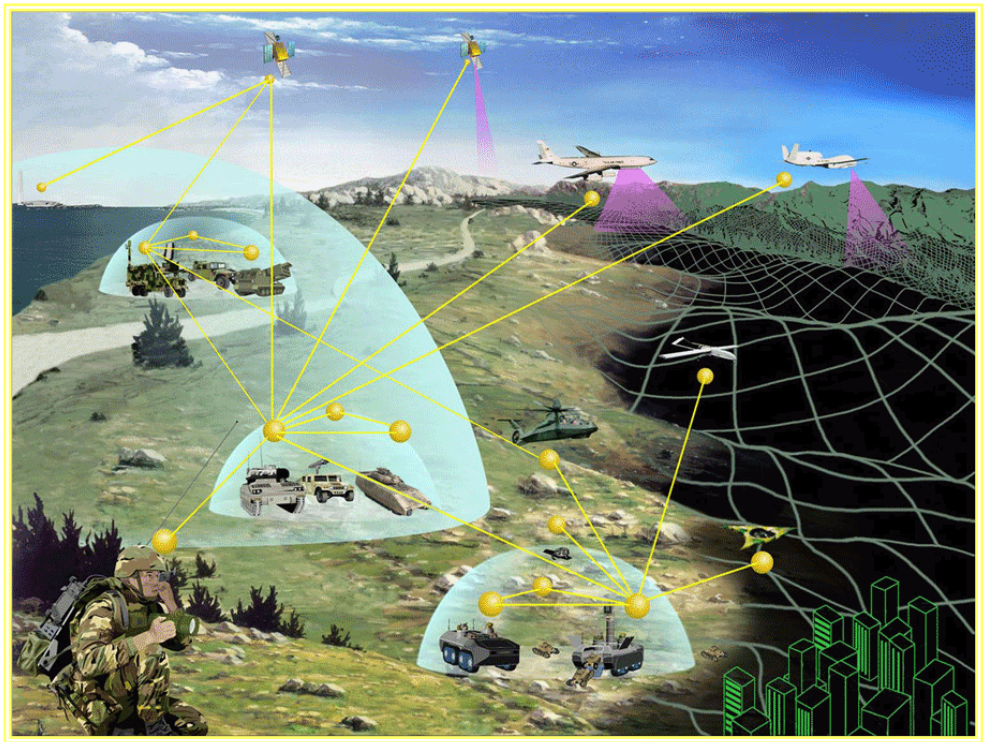
Opportunities for Improvement

- Software and System development tool suites must:
  - Automate tasks not done consistently well by humans
    - Code generation
    - Enforcement of architectural policies
  - Provide consolidated system-awareness
    - Service, resource and application prioritization
    - Design trade-offs
  - Simplify testing and verification

Army Future Combat System Challenges

"The software task alone is five times larger than that required for Joint Strike Fighter and ten times larger than the F-22, which after two decades is finally meeting its software requirements."

- Congressman Curt Weldon, House Armed Services Committee tactical air and land forces subcommittee hearing April 1, 2004 as quoted in Defense News April 12, 2004



- **Emphasis on network dependence**
- **V&V will be difficult**

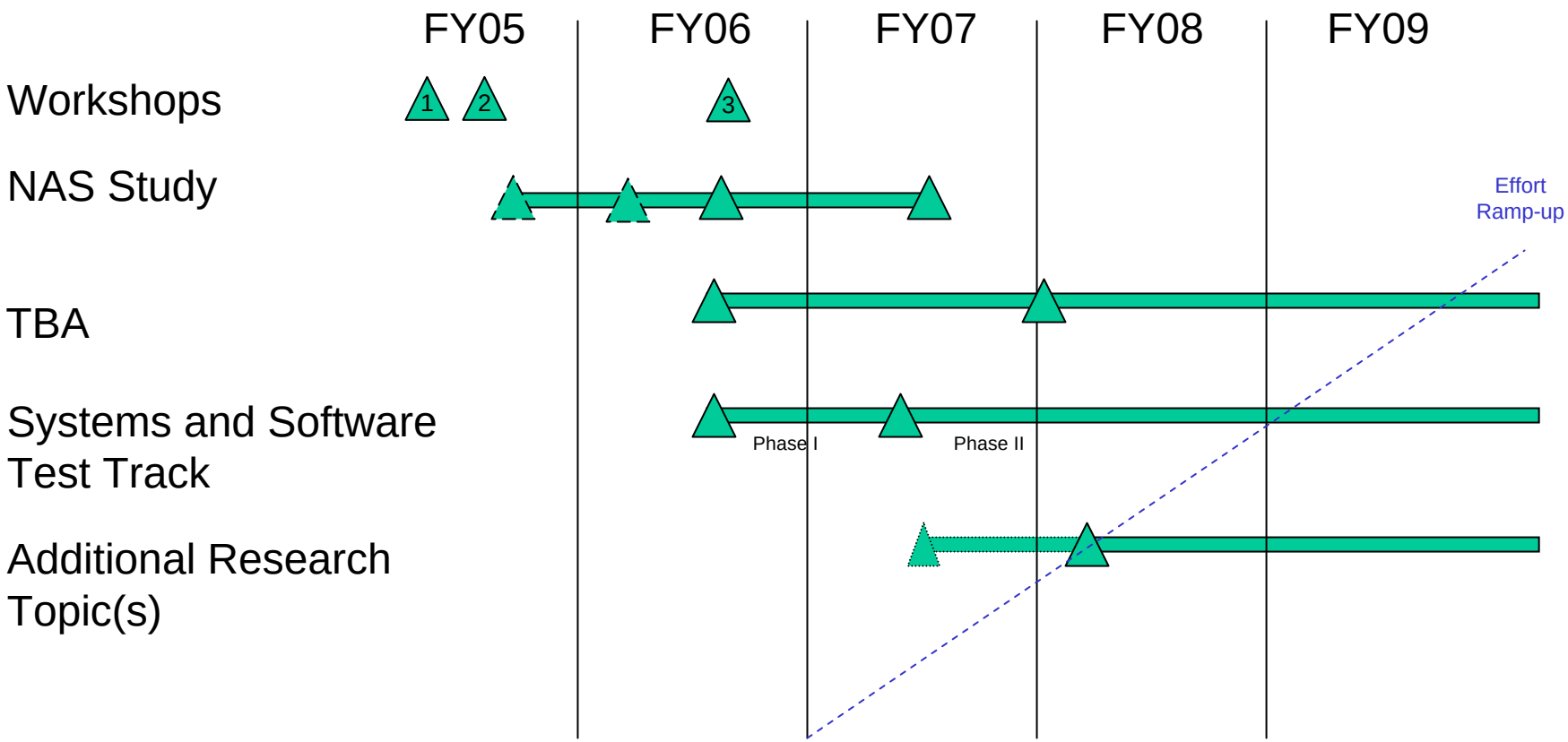
Opportunities for Improvement

- Development environments for net-reliant embedded systems must:
  - Readily embrace emerging data and knowledge management strategies
  - Automatically facilitate and assess interoperability protocol implementation compatibility
  - Address system-of-systems design
    - Properties-in-the-large, composeability, security
  - Accommodate data and functional uncertainties associated with ad-hoc networks and transient application relationships
- System-of-Systems Verification

Emerging Interests

- Software Assurance
  - Ensuring applications and infrastructure are free from vulnerabilities and malware
- Open Technology Development
  - Open Source
  - Open Standards

Overview – Existing Program



Workshops

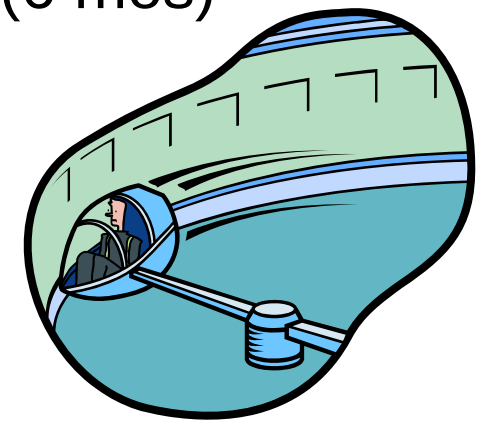
- #1 Establish Overall Research Agenda
  - Held May 17/18 2005 - ZAI, Rosslyn VA
- #2 Establish Research Goals, Infrastructure Requirements
  - Held July 2005 – UC Berkeley
- #3 Industry – Transition & Motivation
  - Scheduled for May 17-19 2006
    - ZAI Rosslyn VA
  - Include Gov/Industry Exec Session May 19

National Academies Study

- FY05-07 (2 year effort),
  - Independent expert committee (15), Workshops, Interim & Final reports
- Assess
  - Progress in tech base
  - R&D organization
  - Tech transition
  - Long-term SIS maintenance and evolution
- Recommend National-scale SIS S&T investments
  - Collaborate with other Federal investments

Systems and Software Test Track

- Purpose
  - Bring researchers together with developers and development artifacts to ‘test drive’ emerging technologies and techniques
- Activities
  - FY06 – Phase 1 Planning and Definition (6 mos)
    - Scope, funding estimate, programmatics
  - FY07 – Implementation
    - Establish facility
    - Begin populating with developer products,
  - FY08 –
    - Full operations
    - Allow researchers to apply innovative tools, technologies and techniques



Other On-going Activities

- STTR topics
  - Error Handling paths and policies analysis
  - Security Escorts for Not-Yet-Trusted software
  - Software System Reliability Analysis
  - Assessing Interoperability Through Cross-Domain Protocol Compatibility Analysis
- HPEC-SI
  - Signal processing library
- SBIR Topics
  - Design Visualization
  - Malicious Code Diffuser
  - Robust Complex Systems
  - Software Test Engineering: Analysis of Trace Semantics
  - A Software Hub for High Assurance Model-Driven Development and Analysis
  - Software Verification
- Open Technology Development
  - Blend of open source and open systems approaches

What We Need . . .

- A 7 year, $20-32M per year investment in software-intensive systems development technologies
  - Research
  - Testing
  - Transition

Return on Investment (ROI)

Combined Improvement ROI

	10% Improvement in Productivity	20% Improvement in Productivity	50% Improvement in Productivity
10% Reduction in Rework	7:1	11:1	21:1
20% Reduction in Rework	9:1	**14:1**	24:1
50% Reduction in Rework	16:1	20:1	30:1

- Assumptions
  - New effort, 7 year investment
  - Calculated for 10 future acquisition programs
  - Based on estimated industry productivity[1] and rework for DoD systems[2]

1 – DACS Software Tech News Volume 7, Number 2 Article "Industry Software Cost, Quality and Productivity Benchmarks" by Donald Reifer, June 2004
2 – GAO report 04393, title "Stronger Management Practices Are Needed to Improve DOD's Software-Intensive Weapon Acquisitions", dated March 2004

DoD Software S&T

- Current State of Play:
  - Research investments tailing off
  - Government expertise-base has atrophied
  - Software tools and techniques sometimes developed by acquisition programs themselves
  - CMU Software Engineering Institute focused on SWE process and transition, not advancing technology base
- Missed Opportunities: No DoD-wide approach to
  - Working with acquisition programs to address common SW technology issues
  - Developing standards (e.g., CORBA, UML)
  - Engaging 3rd-party software vendors (e.g., Rational (IBM), Mathworks, Green Hills Software)

What about Industry?

- Industry investments are usually inappropriate for DoD problems
  - Research is targeted for specific products, not general long-term improvements
  - Focused on selling software products – quality and reliability are lower priorities
  - Global resourcing for research and development limits applicability to DoD
- For Defense contractors -
  - Software may not be a direct profit driver
  - Software technologies difficult to retain as company IP

Envisioned Program Overview

- **Description**:
  - Reinvigorate SIS development research and provide dedicated efforts to demonstrate and transition improvements to acquisition programs
  - Enable DoD engineers and industry partners to develop and acquire SIS with reasonable and repeatable cost, schedule and performance
- **Benefit:** What is the benefit to the Department?
  - Increase efficiency, reduce cost and schedule overruns, and reduce critical failures associated with software for warfighting and management
  - Successful development of software that meets our growing expectations in software program size and complexity
- **Major Elements:**
  - Research - Technologies, Tools and Techniques
  - Systems and Software Test Track
  - Transition

Previous DoD S&T Investments Have Had a Major Impact

Examples:

- Real-Time Computing: an Efficient Principled Approach to Process Task Coordination and Schedulability
- MoBIES: Model-Based Integration of Embedded Software for Design and Testing
- Quorum: Quality-of-Service Middleware for Robust, Portable Mission-Critical Applications capable of Adapting to the Dynamic, Uncertain Conditions of Network-Centric Warfare

Call for Action

- DoD needs to reinvigorate its investments in software and systems development technologies
  - Increased dependence on software
  - Common problem for acquisition programs
- This Cross-Component issue necessitates a jointly coordinated effort
  - We welcome cooperation with Industry, Academia and other Federal agencies